SUPPORT
BONE TISSUE

PHYSIOLOGY:
The skeletal system has many functions. Among them are: support and protection of the body, movement, blood formation, mineral homeostasis, electrolyte and acid-base balance, and detoxification.

ANATOMY
The structure of bone:

1. Diaphysis: shaft of a long bone
2. Epiphyses: the extremities at ends of the bone
3. Metaphysis: the region in the long bone where the diaphysis joins the epiphysis: In growing bones the epiphyseal plate is where the bones grow in length.
4. Articular Cartilage: thin layer of hyaline cartilage covering the epiphysis
5. Periosteum: membrane around the surface of the bone not covered by articular cartilage
6. Medullary or Marrow Cavity: space within the Diaphysis that contains yellow marrow
7. Endosteum: membrane that lines the Medullary cavity

SHAPES AND GENERAL FEATURES OF BONES

Long Bones have greater length than width, consist of a shaft and a variable number of extremities, and are slightly curved for strength. They consist primarily of compact bone, but also contain much spongy bone and include bones of the legs, arms, fingers and toes.

Short Bones are somewhat club shaped, nearly equal in length and width, and consist of spongy bone except at the surface where there is compact bone. Examples are the wrist and ankle bones.

Flat Bones are generally thin and composed of two parallel plates of compact bone enclosing a layer of spongy bone. They offer considerable protection and provide extensive area for muscle attachment. Examples include cranial bones, sternum, ribs and shoulder blade.

Irregular Bones have complex shapes and cannot be grouped into any of the other types. They vary in amount of compact and spongy bone present. They include backbone and certain facial bones.
HISTOLOGY OF BONE TISSUE

The cell types found in bone tissue are the osteogenic or osteoprogenitor cells (base cell from which all connective tissue is derived), the osteoblasts (cells that form bone, yet can’t undergo mitosis; secrete collagen, and other components that build bone), osteocytes (mature bone cells and principle cells of bone tissue that reside in tiny cavities called lacunae), and osteoclasts which function in bone resorption.

**Compact Bone** tissue consists of osteons with little space between them. They lie over spongy bone and compose most of the bone tissue of the diaphysis. Its function is to support, protect and resists stress of weight.

**Spongy Bone** tissue on the other hand does not contain osteons, consists of trabeculae surrounding many red marrow filled spaces, and forms most of the structure of short, flat, and irregular bones, and the epiphysis of long bones. Its function is to store red marrow and provide some support.

**Bone Marrow** refers to the soft tissue that occupies the medullary cavity of long bones and the trabeculae of spongy bones and in the larger central canals. Red bone marrow is hemopoietic tissue and thus makes blood cells. Yellow bone marrow is red bone marrow that has turned fatty in young to middle-aged adults and serves as energy storage.

**PHYSIOLOGY OF BONE FORMATION: OSSIFICATION** – Bone tissue is constantly rebuilding and changing shape. There are two types of ossification; intramembranous and endochondral. In **intramembranous ossification**, bone formation is directly on or within the fibrous connective tissue membranes. This is easily seen in the skull bones and inside layer of the periosteum. It occurs within fibrous membranes of the embryo and the adult. At the site where bone will develop, mesenchymal cells become vascularized, cluster, and differentiate into osteoprogenitor cells and then into osteoblasts which secrete the organic matrix of bone. As the matrix forms, it develops trabeculae and the trabeculae from various centers fuse together to form spongy bone. On the outside of the bone, vascularized mesenchyme develops into the periosteum. Some of the spongy bone will be replaced by compact bone.

In **endochondral ossification**, formation of bone occurs within a cartilage model. Most bones form this way. The primary ossification center of a long bone is in the diaphysis. Cartilage degenerates, leaving cavities that merge to form the medullary cavity. Osteoblasts lay down bone. Next, ossification occurs in the epiphysis, where bone replaces cartilage, except for the epiphyseal plate.
PHYSIOLOGY OF BONE GROWTH AT THE EPIPHYSEAL PLATE

An epiphyseal plate consists of layers of cells: resting cells, young dividing cells, older enlarging cells, and dying cells. The epiphyseal plate is responsible for lengthening of the bone. Long bones tend to lengthen until the epiphyseal plate ossifies. **Appositional growth** (growth in bone diameter) is a result of the addition of new bone tissue by periosteal osteoblasts around the outer surface of the bone.

BONE HOMEOSTASIS

Bone is living tissue that is constantly changing. Bone remodeling is the ongoing replacement of old bone tissue by new bone tissue. Even after bone reaches adult shape and size, old bone is destroyed and new bone is formed in its place. Old, worn and injured bone is removed and new bone is laid down. Old bone is destroyed by osteoclasts and new bone is constructed by osteoblasts. The breakdown of bone matrix is called resorption whereas the laying of new bone is called bone deposition. The body requires minerals, vitamins, and hormones for this to happen. For example, the distal end of the femur is replaced about every four months. Remodeling renews bone tissue before deterioration sets in and it is also the way that bone heals. Factors that affect bone growth and remodeling are the amount of minerals (especially calcium and phosphorus), vitamins (C, K and B₁₂), and hormones (parathyroid and calcitonin) present.

Fracture and **Bone Repair**

A fracture is any break in the bone. A closed reduction refers to setting a bone to its original position by manipulation without surgery whereas an open reduction refers to setting the bone during surgery. Repair involves formation of a fracture hematoma, fibrocartilaginous callus (formation of granulation tissue), bony callus and remodeling. A fracture of the epiphyseal plate in a young person may delay or even halt bone growth.

The Bone’s Role in Calcium Homeostasis

Bone is the major reservoir of Calcium ions (Ca++). Bone “buffers” blood calcium levels by releasing calcium when blood levels decrease and taking calcium back when blood levels rise. Hormones that affect homeostasis of bone tissue are parathyroid hormone which increases blood calcium levels by taking Ca++ from the bones and calcitonin which decreases blood calcium levels by depositing Ca++ back into the bones. Calcium is used in muscle and nervous system physiology.

EXERCISE AND BONE

Bone can alter its strength in response to mechanical stress. Removal of stress weakens bone through demineralization and collagen reduction.
AGING AND BONE TISSUE

The principle effect of aging is the loss of calcium in the bones which may result in osteoporosis. A second effect is decreased production of matrix which makes bones susceptible to fracture.

**Why is this chapter important?**

In this chapter we discovered that bone is continuously growing, remodeling, and repairing itself. The functions of bone tissue are: it contributes to homeostasis of the body by providing support and protection; the production of blood cells (hemopoiesis); and the storage of minerals and triglycerides. The cells present in bone tissue are osteogenic cells, osteoblasts, osteoclasts, and osteocytes. We looked at the shape of bones, the differences between compact and spongy bone, the two types of bone formation (intramembranous and endochondral ossification), as well as the steps in fracture repair.

**THE SKELETAL SYSTEM: THE AXIAL SKELETON**

The **Axial Skeleton** consists of bones of the skull, the vertebral column, the thorax and the hyoid bone.

**SURFACE MARKINGS**

On the surface of bones there are many ridges, spines, bumps, canals, and holes. Depressions receive other bones and openings allow blood vessels and nerves to pass into bone. Processes form joints and serve as points of muscle attachment. A list of all the surface features can be seen in table 7.2 of your text.

**SKULL**

The skull contains 22 bones (8 cranial and 14 facial). It rests on the superior end of the vertebral column. The cranial bones enclose and protect brain and include a frontal bone, parietal bones (2), temporal bones (2), occipital bone, sphenoid bone, and ethmoid bone. The frontal bone is the forehead bone. It contains frontal sinuses that lie deep within. These sinuses serve as sound chambers that give voice resonance. The parietal bones form most of the sides and roof of the cranial cavity. The temporal bones form the inferior sides of the cranium and part of the cranial floor. Within the cranium the brain is housed in a space called the cranial fossa. The cranial fossa can be divided into three sections (anterior, middle, and posterior) accommodate different compartments of the brain.
The Sphenoid bone lies at the middle part of the base of the skull articulating with all other cranial bones and holding them together. It forms part of the floor, side walls and rear wall of the orbits. It contains the sphenoid sinuses which drain into the nasal cavity. The greater/lesser wings, sella turcica, optic foramen, superior orbital fissure, pterygoid processes are all found on the sphenoid bone. Other structures and foramen on the sphenoid bone include the carotid foramen, jugular foramen, mastoid foramen, mandibular fossa, articular tubercle, internal and external auditory meatus, and the styloid process.

The Ethmoid Bone is a sponge-like bone located between orbits. It forms part of the anterior portion of the cranial floor, the media wall of the orbits, superior portions of the nasal septum, most of the sidewalls of the nasal roof. Spaces in bone form ethmoid sinuses. Arising from the cribiform plate is the crista galli which serves as a point of attachment for the meninges that cover the brain.

The petrous portion on the floor of the cranial cavity houses the middle and internal ear and the mastoid process serves as a point of attachment for several neck muscles. The occipital bone is the posterior part of the skull and most of the base of the cranium. It contains the foramen magnum through which the medulla oblongata passes. The occipital condyles, hypoglossal canal, external occipital protuberance are located on the occipital bone.

The facial bones have no direct contact with the brain or the meninges. The facial bones include nasal bones (2), maxillae (2), palatine bones (2), zygomatic bones (2), lacrimal bones (2), inferior nasal chonchae (2), vomer, and mandible. The nasal bones form the bridge of the nose. The maxillae unite to form the upper jawbone and it articulates with every bone in the face except the mandible. It contains maxillary sinuses. The roots of teeth reside in a deep socket called an alveolus. The Palatine bones form posterior portion of the hard palate. The zygomatic process joins with the zygomatic bone to form the zygomatic arch (cheekbones). The Lacrimal bones are the smallest bones in the face. The Vomer forms inferior and posterior part of the nasal septum. Inferior nasal chonchae (turbinates) allow more surface area in the nasal cavity. Paranasal sinuses are paired cavities found in the frontal, sphenoid, ethmoid and maxillae.

The Orbits of the eye are formed by seven bones of the skull: frontal, sphenoid, palatine, zygomatic, lacrimal, ethmoid, and maxilla.

The Mandible or lower jawbone contains a body, rami, condylar process (that articulates with fossa of temporal bone), coronoid process (for muscle attachment), mandibular notch, and an alveolar process. There are two foramen of note: the mental and mandibular. The mandibular foramen is used by dentists to inject anesthetics. Foramina in all bones allow communication for blood, lymph, and neural information, between the interior and exterior of the skull.

Finally, the Hyoid Bone does not articulate with any other bone, but supports the tongue and provides attachment for muscles of the neck and pharynx.
Sutures
A suture is an immovable joint. The cranial sutures include a coronal suture which is between frontal bone and two parietal bones, a sagittal suture found between two parietal bones, a lambdoid suture between parietal bone and occipital bone, and a squamous suture between parietal bones and temporal bones.

Fontanels are dense, connective tissue membrane-filled spaces between the cranial bones of fetuses and infants. These are also called the “soft spots” on an infant’s head. They enable the infant’s head to modify its size and shape as it passes through the birth canal and permits rapid growth of the brain during infancy. They also allow the physician to gauge the degree of brain development by their state of closure. The anterior (frontal) is located between the angles of two parietal bones and two segments of the frontal bone. The posterior occipital is found between two parietal bones and the occipital bone. Anterolateral (sphenoidal) are on each side of the skull at the juncture of the frontal, parietal, temporal, and sphenoid bones and posterolateral (mastoid) are located on each side of the skull at the junction of the parietal, occipital, and temporal bones.

VERTEBRAL COLUMN

The vertebral column along with the sternum and the ribs form the skeleton of the trunk of the body. Its function is to enclose and protect the spinal cord, support the head, and serve as a point of attachment for the ribs and muscles of the back. The vertebral column is composed of seven cervical vertebrae, twelve thoracic vertebrae, five lumbar vertebrae, five sacral vertebrae which fuse into one bone (sacrum), and four coccygeal vertebrae which fuse into two bones (coccyx). Between vertebrae are intervertebral discs, the outer portion consists of fibrocartilage and is called annulus fibrosus. A soft, elastic inner portion called nucleus pulposus. These discs form strong joints, permits various movements and absorbs vertical shock.

Normal Curves of the vertebral column increase strength, help maintain balance in the upright position, absorb shocks from walking, and protects the column from fracture. The primary (thoracic and sacra or pelvis) is anteriorly concave and the secondary (cervical and lumbar) is anteriorly convex. The cervical curve develops when baby holds his head up and the lumbar curve develops when baby stands.

Typical vertebrae have a body, the thick, disc-shaped portion that bears the weight, and a vertebral arch that extends posterior to the body and with the body
surrounds the spinal cord. The vertebral arch is formed from the pedicle, lamina, and the body of the vertebra. Processes that arise from vertebral arch are the transverse and spinous and are used for muscle attachment. The superior articular (2) and the inferior articular (2) facets form joints with other vertebrae.

The first cervical vertebra (C1) is the atlas. Its articulation permits head to signify yes. The second cervical vertebra (C2) is called the axis, and it contains a structure (dens) that permits the head to rotate, signifying no. In the Thoracic Region, the twelve bones are larger and stronger than cervical vertebrae. Here the facets and demifacets articulate with the ribs. The five bones of Lumbar Region are the largest and strongest vertebrae because of their role in the support of the body’s weight. The Sacrum, a triangular bone formed by fusion of 5 bones, serves as foundation of pelvic girdle. The sacral promontory (superior border of sacrum) is used as obstetrical landmark; the auricular surface articulates with ilium of each hipbone. The Coccyx is the tailbone. The vertebral foramen houses the spinal cord. The intervertebral foramen permits passage of a single spinal nerve between the vertebrae. The transverse foramen allows vertebral artery, vein and nerve to pass through as does the anterior and posterior sacral foramen.

The function of skeleton of the THORAX is to enclose and protect organs in the thoracic cavity and upper abdomen and to provide support for bones of the shoulder girdle and upper extremities. It consists of the Sternum or breastbone. Sections of the sternum are labeled manubrium, body, and xiphoid process. The body of the sternum articulates with the second through tenth ribs. There are twelve pairs of Ribs. The first through seventh (vertebrosternal ribs) pair attach directly to sternum by a strip of hyaline cartilage (coastal cartilage) and are the true ribs. Pairs 8-10 are called false ribs (vertebrochondral ribs) because their coastal cartilage’s either attached indirectly to sternum or not at all (floating ribs, 11-12). The ribs may be labeled head, neck, coastal angle, and coastal groove.

**Why is this chapter important?**

The bones of the axial skeleton contribute to homeostasis by protecting many of the body’s organs, especially the brain, spinal cord, heart and lungs. These bones are also important in calcium storage and release. We learned the identity and location of eighty of the body’s 206 bones and the purpose and description of bone surface markings.